JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1979, 31, 405-420 NUMBER 3 (MAY)

CONDITIONAL DISCRIMINATION AFTER ERRORLESS AND TRIAL-AND-ERROR TRAINING[1]

GARY L. SCHILMOELLER, KATHRYN J. SCHILMOELLER, BARBARA C. ETZEL, AND JUDITH M. LEBLANC

PENNSYLVANIA STATE UNIVERSITY AND THE UNIVERSITY OF KANSAS

Children were trained on a visual discrimination by stimulus shaping, stimulus fading, or trial-and-error. Those who did not acquire the conditional discrimination received a second, different training. More children initially trained by stimulus shaping acquired the conditional discrimination than did those initially trained with stimulus fading or trial-and-error. After a history of fading or trial-and-error training, children were less likely to acquire the conditional discrimination even after the more successful procedure of shaping was later used.

Key Words: errorless discrimination, fading, stimulus fading, stimulus shaping, shaping, conditional discrimination, discrimination, preschool children

In one of the earliest unequivocal examples of discrimination learning without errors, Terrace (1963a) emphasized the early introduction of the incorrect or distracting stimulus (S−) and the progressive alteration of that stimulus until it became the criterion S− stimulus. Pigeons were taught to peck in the presence of a red key (S+) and to withhold pecking in the presence of a green key (S−) in a successive discrimination paradigm. During training, the S− was gradually introduced (faded in) along the dimensions of duration and intensity. This stimulus-fading technique has been used subsequently to train visual discrimination in simultaneous discrimination paradigms involving human subjects. In those studies, the correct choice (S+) appeared at the final or criterion intensity from the outset of training. The distractors (S−) were gradually faded in until they reached the same intensity as the S+. For example, Moore and Goldiamond (1964) taught normal preschool children to match triangles on the basis of angle rotation, and Sidman and Stoddard (1966, 1967) taught normal and retarded children a circle-ellipse discrimination.

Demonstration of the effectiveness of stimulus fading has been limited to simple discriminations. The procedures do not seem to facilitate transfer to conditional discriminations based upon those simple discriminations (Gollin & Savoy, 1968; Guralnick, 1975). Using fading, Gollin and Savoy attempted to train two discriminations separately: (a) to select a triangle when shown a triangle and circle with a common single-stripe background and (b) to select a circle when shown a triangle and circle with a common multiple-stripe background. Following training, the two discriminations were randomly intermixed to test for transfer to the conditional discrimination. When fading did not facilitate transfer, Gollin and Savoy noted that the gradual introduction of S− in fading does not expose subjects to the final differences between the stimuli early in the discrimination-acquisition process. They suggested that the opportunity to compare the final stimuli was insufficient for effective transfer to the conditional discrimination.

Attempts to establish even simple discriminations using stimulus fading procedures designed to preclude or diminish errors during training have not always been successful. Kar-

[1]This manuscript is based on the dissertation of Gary L. Schilmoeller, advised by Judith M. LeBlanc, and submitted to the University of Kansas in partial fulfillment of the requirements for the PhD. The research was sponsored in part by Grant HD-02528 to the Department of Human Development by the National Institute of Child Health and Human Development, and by DHEW Research Service Award HD 07066 from the Institute of Child Health and Human Development to the Kansas Center for Mental Retardation and Human Development. A special word of thanks to M. Elizabeth Stella, who drew the stimuli used in the stimulus shaping programs. Reprints may be obtained from Gary L. Schilmoeller, Division of Individual and Family Studies, Pennsylvania State University, University Park, Pennsylvania 16802, or Judith M. LeBlanc, Department of Human Development, The University of Kansas, Lawrence, Kansas 66045.

picke and Hearst (1975) reported success with only 9 of 61 pigeons in an attempt to replicate Terrace (1963a) systematically. Cheney and Stein (1974) found that stimulus fading enabled kindergarten children to respond with few errors during training on an oddity task but did not result in errorless responding on the final task. Similarly, Koegel and Rincover (1976) indicated that the superimposition and subsequent fading of color cues enabled autistic and normal children to respond with no errors during training of two choice visual discriminations. However, errorless responding was not maintained when the color cues were removed. Guralnick (1975) and Cheney and Stein concluded that the results of their research were consistent with those of Gollin and Savoy (1968); i.e., subjects' attention was oriented toward the intensity stimulus dimensions manipulated during fading rather than dimensions critical to the final discrimination.

Although stimulus fading has not always established simple discriminations without errors or facilitated transfer, a growing literature reports that the use of other progressive stimulus manipulations can result in errorless or near errorless acquisition of discriminations by humans. One such procedure, sometimes called stimulus shaping, involves manipulating the topographical configuration of visual stimuli.[2] Bijou (1968) demonstrated that progressively changing the topography of distractors in a left-right discrimination program resulted in correct responding during training as well as on the final task. Conversely, Bijou found that fading only the size of distractors produced many errors on the final discrimination. Stimulus shaping has also succeeded in programs designed to teach the identification of a reversed *C* presented in an array of four regular *C*'s (program developed by McCleave, reported by Baer, 1970) and in programs developed to teach the correspondence between *kanji* (Japanese characters) and representative pictures (Schilmoeller & Etzel, 1977). Similarly, after using fading to establish a circle-ellipse (S+-S−) discrimination, Sidman and Stoddard (1966) used stimulus shaping to maintain errorless performance while transferring the S+ value from the circle to the ellipse. If intensity fading misdirects subjects' attention, these studies suggest that perhaps stimulus shaping focuses their attention on those stimulus dimensions that are ultimately critical for correct responding on the final discrimination.

For constructing errorless programs, Schilmoeller and Etzel (1977) suggested that an important variable is the manipulation of stimulus cues that are related to the final, or criterion, discrimination. For example, in the programs designed to teach *kanji* representations of pictures, the S+ was initially identical to the sample picture. Over successive trials, the progressive topographical changes shaped the pictures into the appropriate *kanji*. The shaping changed those elements critical to the final discrimination. After demonstrating errorless learning, Schilmoeller and Etzel demonstrated that children's attention could be distracted from the critical elements of the stimuli by superimposing cues unrelated to the criterion discrimination upon the stimuli of the successful shaping program. Addition of these noncriterion-related cues did not disrupt correct responding during training, but errors did occur on the criterion discrimination after the added cues had been faded out.

According to the above logic, the relative effectiveness of fading or shaping would depend on the nature of the final task. For example, to establish a fine discrimination between two shades of gray, intensity fading likely would be successful as a progressive manipulation of a cue critical to the final task. Conversely, intensity would not be considered a criterion-related cue in the conditional discrimination used by Gollin and Savoy (1968) inasmuch as the final task was a form-background discrimination. Subjects might attend to the intensity dimension being faded rather than the form-background combinations critical to the final discrimination.

[2]Sidman and Stoddard (1967, p. 3) first used the term "stimulus shaping" and suggested that the procedure was analogous to "response shaping." However, the distinction between stimulus shaping and stimulus fading was not made explicit by these investigators since they and others have subsequently used fading and shaping interchangeably. In a working paper (Etzel & Schilmoeller, 1977), Etzel suggested a distinction be made between the two since the application of shaping or fading appears to be dependent on the differences in the dimensions of S+ and S− stimuli. A copy of this review may be obtained from Barbara C. Etzel (Bureau of Child Research, University of Kansas, Lawrence, Kansas 66045) by requesting the John T. Stewart Children's Center Working Paper #100.

The present study used topographical shaping to establish, in preschool children, the two simple discriminations comprising the conditional discrimination problem of Gollin and Savoy (1968). The purpose was to compare these stimulus shaping programs with an intensity-fading program and with trial-and-error training. The comparison was based on the number of errors emitted during training and on the conditional discrimination. These comparisons replicate the work of Gollin and Savoy and extend their analysis to another method of progressive stimulus manipulation—stimulus shaping.

METHOD

Subjects and Setting

Forty normal 4- and 5-yr-old children from the Edna A. Hill Child Development Laboratory at the University of Kansas served. As they became available from the various classrooms, they were divided into three groups. Table 1 gives sex, age, and training histories of the three groups.

Research sessions were conducted in an approximately 2.4-m by 1.8-m experimental room near the classrooms. A child-sized table and two child-sized chairs faced a one-way mirror between the experimental room and an observation room. During sessions, the child sat to the left of the experimenter, facing the one-way mirror. A notebook containing stimulus materials and two cups used for the token feedback system were placed on the table in front of the child. Each group of children first received training on one of the three stimulus-training materials (either shaping, fading, or trial-and-error) and then a conditional discrimination test.

Stimulus Materials

Figure 1 shows two simple discriminations. Series I stimuli consisted of an equilateral triangle (S+), 5.7 cm on a side, and a circle (S−), 5 cm in diameter. Each form was centered on a 12.8-cm white card. A single black line divided each card in half horizontally. This line extended to within .6 cm of each side of the card and each side of the form, but did not intersect the form. The stimuli for Series II were identical to those of Series I, except that seven horizontal lines formed a multiple stripe background, and the S+ and S− values were reversed. The distance between these seven horizontal lines was 1.27 cm with two exceptions: the distance between the second and third lines from the top and between the fifth and sixth lines from the top was 2.54 cm.

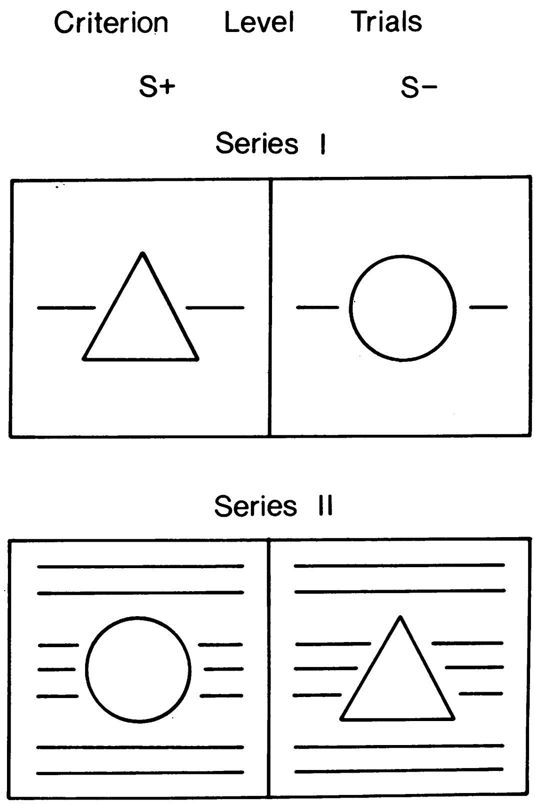

Fig. 1. Criterion stimuli for Series I and Series II.

Three sets of training materials were used, one for stimulus fading, one for stimulus shaping, and one for trial-and-error (criterion level) trials. Stimulus fading here means increasing the contrast of the line drawings on a white background, while stimulus shaping means manipulation of the topographical stimulus configuration. A fourth set of materials, which all training groups received, was the criterion conditional discrimination, made up of trials that intermixed Series I and II as shown in Figure 1.

The stimuli were presented in a three-ring notebook. The two stimuli for each trial were placed on a single page, enclosed in clear plastic. When trials for the two simple discriminations were presented successively within the

Table 1

Descriptive characteristics of subjects, training sequences, and conditional discrimination performance.[a]

Subject	*Sex*	*C.A.*	*Training 1*	*Percentage correct*	*Training 2*	*Percentage correct*	*Experimenter*
GROUP I							
S1	M	4-2	Shaping	25%	Fading	75%	1
S2	M	5-1	Shaping	100%			2
S3	F	4-7	Shaping	92%			1
S4	M	5-4	Shaping	100%			2
S5	M	5-2	Shaping	100%			2
S6	F	4-7	Shaping	100%			2
S7	M	5-6	Shaping	58%	Fading	100%	2
S8	M	5-5	Shaping	33%	Fading	25%	2
S9	F	4-6	Shaping	50%	Fading	100%	2
S10	M	4-8	Shaping	100%			2
S11	M	4-8	Shaping	100%			2
S12	F	4-11	Shaping	100%			2
S13	M	4-11	Shaping	100%			2
S14	M	5-4	Shaping	92%			2
S15	F	4-8	Shaping	92%			2
S16	M	4-11	Shaping	100%			2
	$\bar{X}$ = 4-11						
GROUP II							
S17	M	5-1	Fading	58%	Shaping	33%	2
S18	F	5-7	Fading	50%	Shaping	42%	2
S19	F	4-8	Fading	67%	Shaping	100%	2
S20	F	4-8	Fading	92%			1
S21	F	4-11	Fading	100%			2
S22	F	5-9	Fading	58%	Shaping	75%	1
S23	M	5-6	Fading	42%	Shaping	67%	1
S24	M	5-0	Fading	33%	Shaping	75%	2
S25	M	5-0	Fading	100%			2
S26	M	4-10	Fading	42%	Shaping	42%	2
S27	M	4-10	Fading	50%	Shaping	58%	2
S28	F	4-11	Fading	50%	Shaping	50%	2
S29	M	4-10	Fading	25%	Shaping	25%	2
S30	F	4-8	Fading	50%	Shaping	33%	2
S31	F	5-3	Fading	42%	Shaping	100%	2
S32	M	4-10	Fading	50%	Shaping	42%	2
	$\bar{X}$ = 5-0						
GROUP III							
S33	M	4-6	Trial-&-error	50%	Shaping	50%	2
S34	F	5-4	Trial-&-error	33%	Shaping	17%	2
S35	M	4-4	Trial-&-error	50%	Shaping	42%	2
S36	M	4-5	Trial-&-error	50%	Shaping	42%	2
S37	F	4-11	Trial-&-error	50%	Shaping	50%	2
S38	F	4-9	Trial-&-error	50%	Shaping	33%	2
S39	F	4-11	Trial-&-error	100%			2
S40	F	4-11	Trial-&-error	92%			2
	$\bar{X}$ = 4-9						

[a]Calculated as a percentage correct on a 12-trial test.

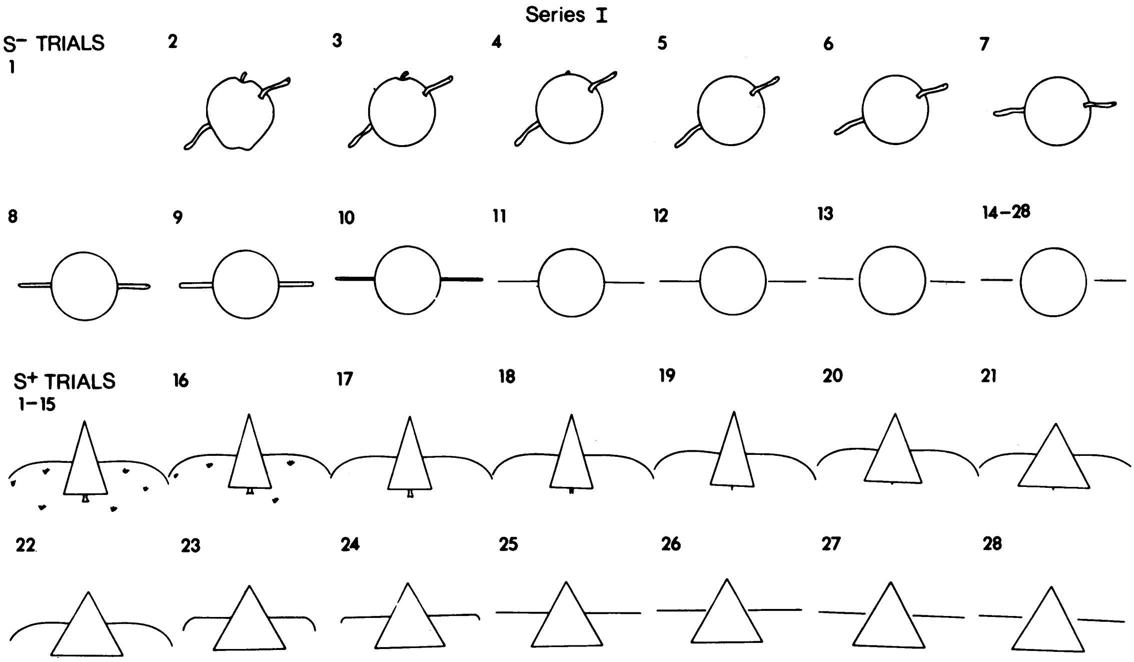

Fig. 2. Shaping steps for both S+ and S− for Series I.

same session, a divider page separated stimuli of the two programs.

Stimulus shaping programs. Since the conditional discrimination required subjects to attend to both form and background, we reasoned that to be criterion related, the initial training stimuli should integrate both form and background into a single stimulus compound. Figure 2 depicts the progressive shaping of stimuli for Series I. On the initial trial, the S− was a blank white card included to enhance the probability that the subjects would respond to the S+ (tree-on-hill). Beginning with Trial 2, the S− appeared as an apple with a worm. The upper portion of Figure 2 shows the shaping steps for S− during Trials 2 through 13. This shaping occurred while the S+ remained constant as the tree on the hill. From Trial 14 through Trial 28, the S− remained at the final level. Shaping of the S+ from the tree on a hill to the triangle with single stripe background occurred during Trials 16 through 28 (lower half of Figure 2). Both S+ and S− were at criterion level on Trial 28.

Figure 3 shows the shaping steps for Series II. Again on the initial trial, the S+ was presented with only a blank distractor card as the S−. The S+ remained as the sun in the clouds during Trials 1 through 15, and the S− changed from the witch over a broom to the triangle with multiple stripe background for Trials 2 through 14 (Figure 3, upper portion). During Trials 16 through 28, the S− remained at this criterion level while the S+ was shaped from the sun in the clouds to the circle with multiple stripe background (Figure 3, lower portion). Both S+ and S− were at criterion level on Trial 28.

Stimulus fading programs. A second set of programs, similar to those originally designed by Gollin and Savoy (1968) to preclude errors, involved stimulus fading along an intensity or contrast dimension. For both Series I and Series II, the fading procedures were identical (Figure 4). S+ stimuli, black lines on a white background, appeared at full contrast for all trials. Contrast was varied for the fading of S− stimuli by using lead pencils of graduated degrees of hardness (No. 4 to No. 1), a black-ink fine-tipped ballpoint pen, and three felt-tip pens with tips of graduated thickness. The S− stimulus lines were faded from white to fully black in two parts. Over the first 10 trials, the geometric form was faded in with one trial at each contrast level. Starting with Trial 11, the background lines were faded in, with two trials at each contrast level, until

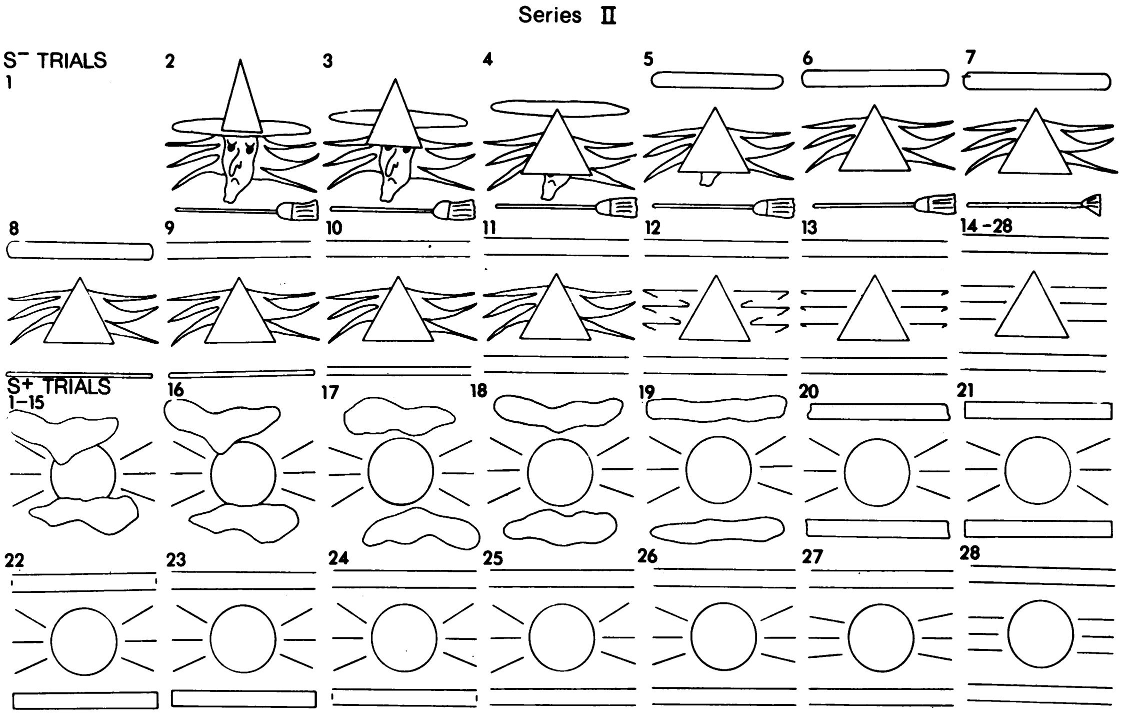

Fig. 3. Shaping steps for both S+ and S− for Series II.

the background reached full intensity. At each contrast level, the first trial consisted of the appropriate background appearing as dashed lines. On the second trial at the same contrast level, the background appeared as solid lines. The addition of the steps using the dashed lines at each contrast level was necessary to equate the number of program trials with those of the stimulus shaping programs. Sample trials from both Series I and Series II are shown in Figure 4. Trial 28 in each program consisted of both S+ and S− at criterion level and was identical to Trial 28 of the shaping programs.

Traditional discrimination training. For traditional discrimination training (trial-and-error), both S+ and S− stimuli appeared at criterion level on all trials. Series I (Figure 1, upper portion) and Series II (Figure 1, lower portion) each contained 28 trials.

Procedure

Training sessions used materials from both Series I and Series II. Gollin (1966) demonstrated that few 4½- to 5-yr-old children acquired the conditional discrimination (the intermixing of trials from both series) without distributing the training over sessions separated by a time interval. Therefore, to enhance the probability of successful conditional discrimination performance, training of Series I and Series II discriminations (regardless of the type of training) was distributed over four sessions. During each session, subjects received a block of seven trials from Series I and then seven from Series II. A yellow page divided the two blocks of trials in the stimulus notebook. Series I trials were presented first on odd numbered sessions, and Series II first on even numbered sessions.

Criterion-separated test. Following training (fifth session), a criterion-separated test was administered. The test trials consisted of the final stimuli from Series I and Series II. The stimuli from each series were presented separately in six-trial blocks separated by a yellow dividing page in the notebook. This test assessed whether the children had mastered the two simple discriminations before they were presented with the conditional discrimination format.

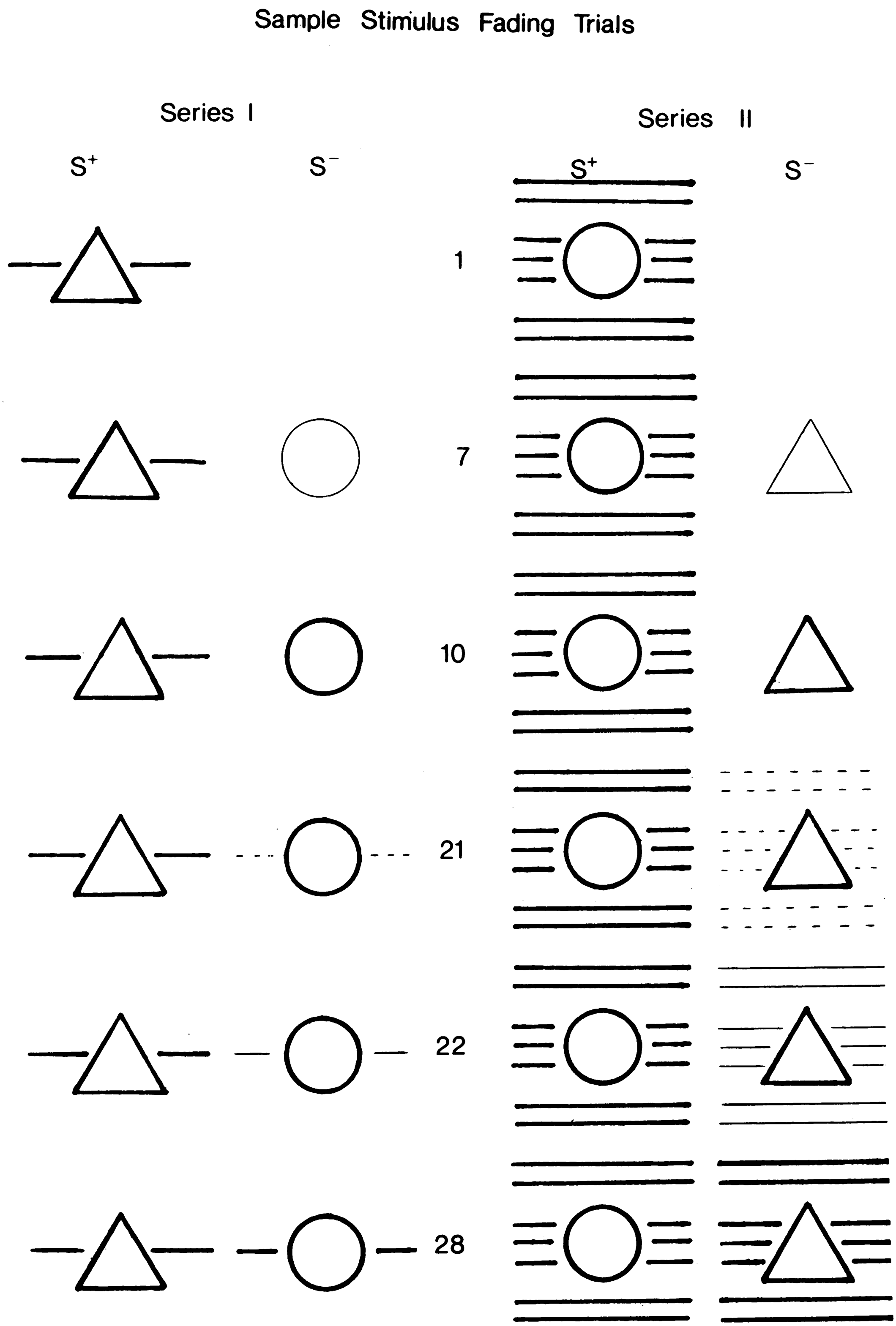

Fig. 4. Sample fading steps for both Series I and Series II. Each step increased contrast by increasing the darkness of the stimulus lines.

Criterion-integrated test. In each training session and on the criterion-separated test, the children were required to shift from one simple discrimination to the other only once. For the conditional discrimination, however, they would have to shift between Series I and II a number of times during the session. The criterion-integrated session was included in this study to facilitate further the transition from training to the conditional problem. The criterion-integrated session contained a block of three trials from Series 1, a block of three trials from Series II, and three additional trials from each Series in a randomly intermixed sequence (thus, the last six trials were the same as the conditional format). Yellow page dividers followed Trials 3 and 6, and all trials were at criterion level.

Conditional discrimination test. To test for the conditional discrimination, six criterion level trials from Series I and II were presented in random sequence with no dividers between trials. The correct choice on any trial was the particular form-background combination reinforced during training.

Rules for position of correct choices. In all training and test sessions, the position of the correct choice was systematically varied as follows: (a) The correct choice appeared in left and right positions equally often each session; and (b) the correct choice was never in the same position on more than three consecutive trials. Never more than two consecutive trials from either Series I or Series II occurred in the conditional discrimination test.

Sequence of conditions. The 16 subjects in Group I initially received stimulus shaping programs for both Series I and Series II (Table 1). Stimulus fading was programmed for a second group of 16 subjects (Group II). Eight additional subjects (Group III) were trained with trial-and-error procedures. Children who did not acquire the conditional discrimination with two or fewer errors after their first training history received a second history. The second history for Group I was fading, and for Groups II and III, it was shaping.

Two experimenters participated in this study. One experimenter conducted all sessions for five subjects. All other subjects were trained and tested by the second experimenter. Table 1 shows the sequence of conditions and the experimenter for each subject.

Daily sessions. Sessions were limited to a maximum of 15 min, and usually only one session was conducted per day. On 18 occasions, two experimental sessions were conducted in one day, but were separated by an interval of 15 min or longer. For Subject 5, the criterion-integrated and conditional discrimination tests were both conducted in one experimental session, as the child was leaving preschool before the scheduled end of the semester.

Experimental sessions followed a consistent format. The experimenter brought the subject to the experimental room and asked the subject to select a toy for which to work. Then the subject was seated at the table and, on the first day, was given these instructions: "Today, I am going to show you some pictures. Whenever you point to the correct picture, I will put a token from my cup into your cup. If you get all of my tokens, you can take your toy home." On subsequent days, the experimenter said, "Remember, you need to get all of my tokens in order to earn your toy."

Each correct choice earned one token. The number of tokens required to earn a toy was determined by the training procedure implemented. For the fading and shaping procedures, the subjects were required to perform at 90% correct levels in each session. For trial-and-error training, the subjects were given their toy regardless of the number of tokens earned for the first session. In subsequent sessions, at least one token more than the number earned the previous session was required for a toy. For example, if a subject responded correctly on 9 of 14 trials in the first session, the token requirement was set at 10 for the subsequent session. If a subject did not earn all the tokens specified for a trial-and-error session, the token requirement decreased by one in each succeeding session until the subject earned them all. Then the incremental rule was reinstated. Subjects trained with trial-and-error procedures never were required to exceed a 90% criterion.

These token criteria were implemented for all trial-and-error training sessions and for the criterion-separated and criterion-integrated test sessions that followed. For the conditional discrimination test session, all subjects, regardless of training history, were instructed to "try to get all of my tokens today." The toy was presented noncontingently at the end of the session.

After the daily token reminder, the experimenter opened the notebook containing the stimulus materials and gave the instructions which were the same for each trial. "Look at both of these pictures. Now point to the one that gets the token." Correct responses were followed by a token plus verbal praise. A correction procedure was used after an incorrect response. The experimenter pointed to the correct choice and said, "This is the correct picture. Now you point to the correct picture." When the child pointed correctly, the experimenter praised the child, but did not deliver a token. This correction procedure was used for all three types of training sessions, for the criterion-separated test, and for the first six trials of the criterion-integrated test. Correction was not used for the last six trials of the criterion-integrated test or for the conditional discrimination test.

Response Measures and Reliability

The position of the subjects' pointing response was recorded, as well as the experimenters' token delivery and use of correction. The experimenter's data recording sheet was premarked to show the position of the correct response. An observer recorded independently from the adjoining observation booth on 198 occasions, including at least 1 session for all but 2 of the 40 subjects. Reliability was assessed during both training and test sessions. The observer used the same data sheet as the experimenter, except that the position of the correct responses was unmarked.

Reliability was calculated for position of the subject's response, token delivery, and use of correction. A percentage agreement was obtained by the formula

$$\frac{\text{Agreements}}{\text{Agreements} + \text{Disagreements}} \times 100$$

Agreement on position of response was 99.5%; on token delivery, 99%; and on the use of correction, 98%.

RESULTS

The data calculations included the percentage of correct responding during the three types of discrimination training as well as during the three different criterion tests (criterion-separated, criterion-integrated, and the conditional discrimination). Also calculated was the percentage of subjects in each group who met the criterion of two or fewer errors on the conditional discrimination. The chance probability of two or fewer errors on a 12-trial test is less than .019. Individual data for the conditional discrimination tests are included in Table 1.

First Training History

Subjects trained with either stimulus shaping (Group I) or stimulus fading (Group II) performed nearly errorlessly during training, with mean percentages of correct responding of 96% during shaping and 95% during fading (Figure 5, top graph). Subjects trained with the trial-and-error procedure (Group III) had a mean of 88% during training. Mean correct responding on the criterion-separated test was 91% after stimulus shaping, 89% after stimulus fading, and 86% after trial-and-error. On the criterion-integrated test, Group I (stimulus shaping) fell to a mean of 84% whereas Group II (stimulus fading) and Group III (trial-and-error) decreased even further to means of 68% and 69%, respectively. On the conditional discrimination, Group I (shaping) remained at a mean of 84%, and the means of Groups II and III further decreased to 57% and 59%, respectively. Groups II and III were then responding just slightly above chance.

The bottom graph of Figure 5 shows that 12 of the 16 subjects (75%) in Group I (stimulus shaping) met the criterion of 2 or fewer errors on the conditional discrimination. Of those 12, 9 performed errorlessly on the conditional discrimination and the other 3 had 1 error each. Only 3 of the 16 subjects (19%) in Group II (stimulus fading) and 2 of 8 (25%) in Group III (trial-and-error) met the criterion on the conditional discrimination. Two of the Group II subjects and one from Group III responded errorlessly. Thus, in terms of both number of subjects meeting the criterion of two or fewer errors and the number of subjects who responded errorlessly, subjects trained with stimulus shaping were more successful on the conditional discrimination than those trained with stimulus fading or trial-and-error.

Second Training History

Subjects who did not acquire the conditional discrimination after their first training

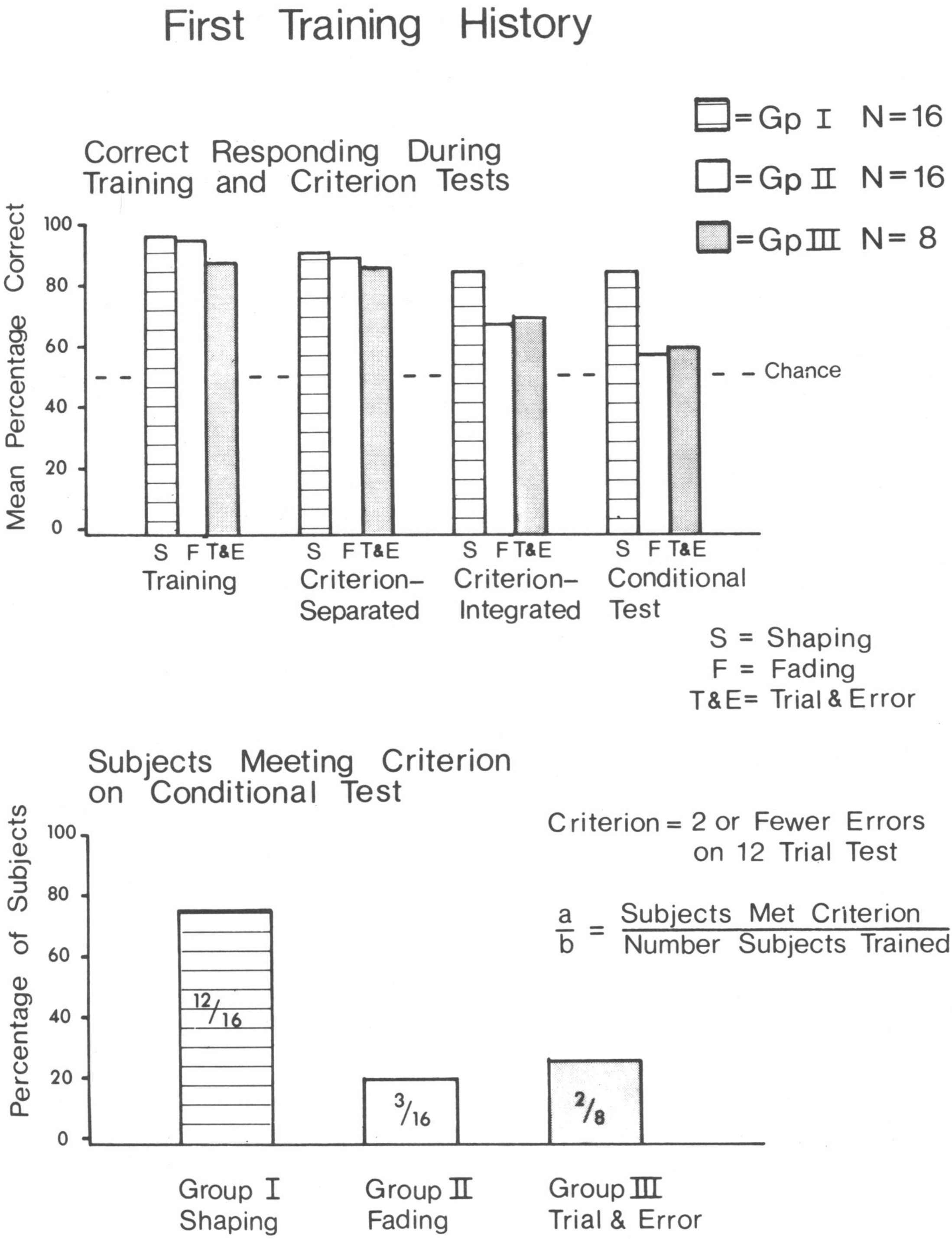

Fig. 5. Top Graph: Mean percentage of correct responses during the first training and the three criterion tests (criterion-separated, criterion-integrated, conditional discrimination test). Bottom Graph: Percentage of subjects meeting a criterion of two or fewer errors on the conditional test.

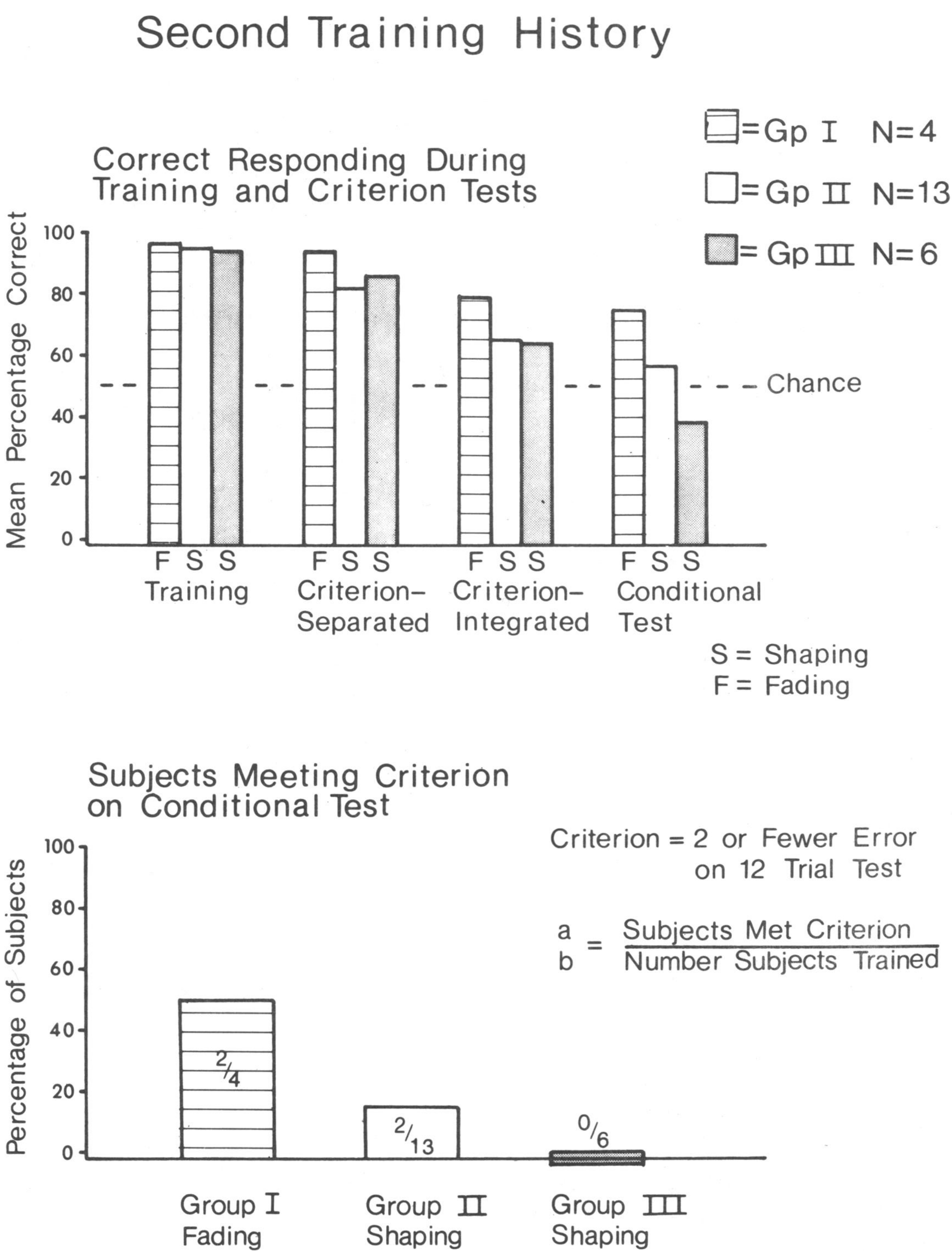

Fig. 6. Top Graph: Mean percentage of correct responses during the second training and the three criterion tests (criterion-separated, criterion-integrated, conditional discrimination test). Bottom Graph: Percentage of subjects meeting a criterion of two or fewer errors on the conditional test.

procedure received a second training history. Group I ($N = 4$), previously trained with stimulus shaping, now received stimulus fading. Group II ($N = 13$) and Group III ($N = 6$), previously trained with fading and trial-and-error, respectively, now were given stimulus shaping.

The means of all three groups were above 90% correct during training, and above 80% correct on the criterion-separated test (Figure 6). On the criterion-integrated test, Group I decreased to a mean of 79% correct. Groups II and III had means of 65% and 64%. On the conditional discrimination, Group I decreased to 75% correct, and Groups II and III performed at 57% and 39%, respectively.

The decline in percentages of correct responding on the conditional discrimination after the second training is reflected in the number of subjects meeting criterion (Figure 6, bottom graph). For Group I, 2 of the 4 subjects (50%) met criterion, and both performed errorlessly. Only 2 of the 13 subjects (15%) in Group II met criterion, and these 2 also performed errorlessly. None of the subjects in Group III met criterion. Therefore,

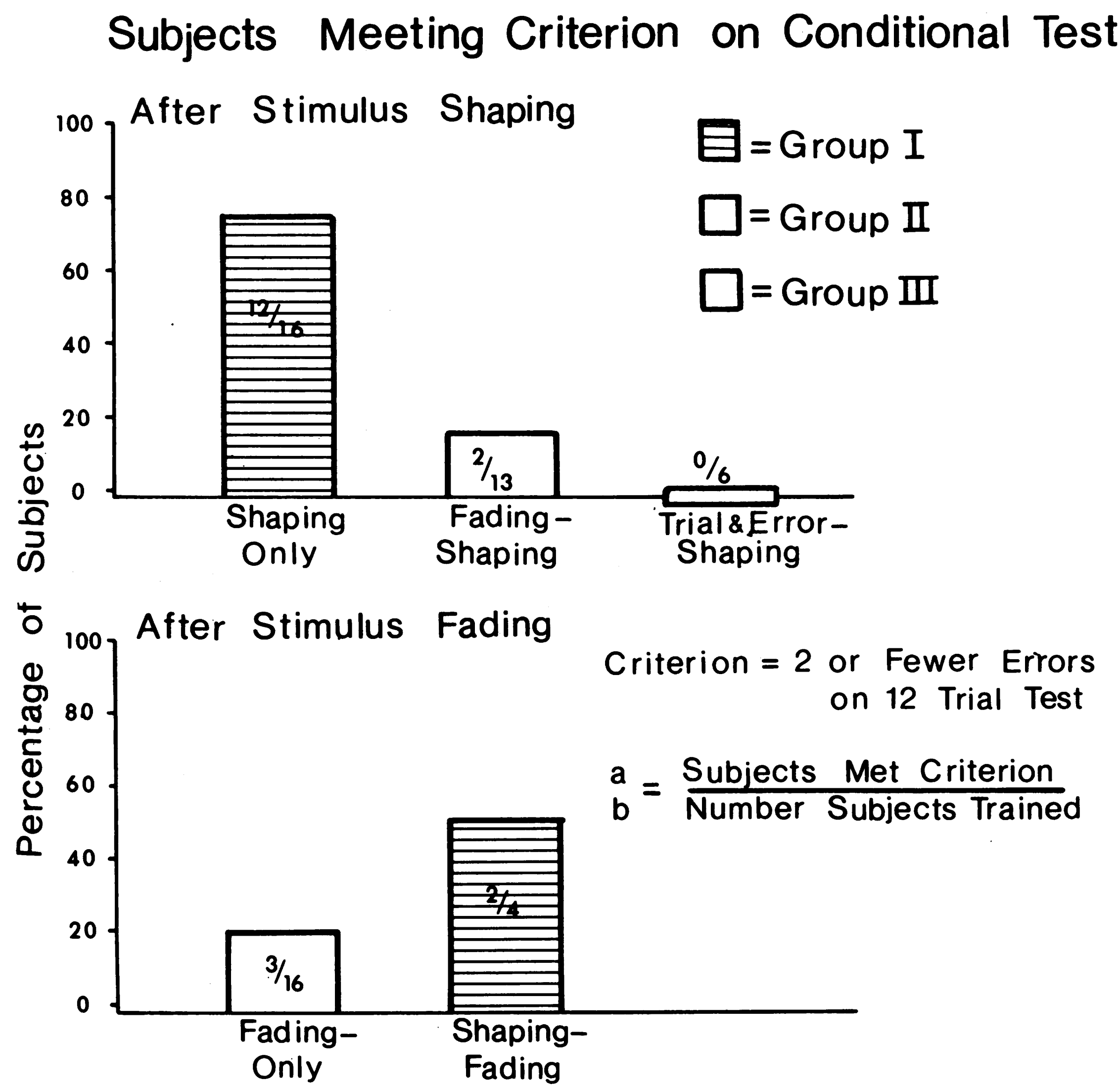

Fig. 7. Top Graph: Percentage of subjects meeting a criterion of two or fewer errors on the conditional test after stimulus shaping. Bottom Graph: Percentage of subjects meeting a criterion of two or fewer errors on the conditional test after stimulus fading.

after the second training history, a higher percentage of subjects trained with stimulus shaping procedures before fading met criterion on the conditional discrimination than those trained with stimulus shaping after fading or trial-and-error procedures.

Comparisons within Procedures

The top graph of Figure 7 compares the number of subjects that met criterion from each group (either after the first or second training history) on the conditional discrimination immediately after stimulus shaping training. With the stimulus shaping program alone (first training history), 75% (12 of 16) of the subjects from Group I acquired the conditional discrimination, and 9 performed errorlessly. Only 15% (2 of 13) of the subjects from Group II met criterion after shaping when there was an earlier history of stimulus fading. None of the 6 Group III subjects met criterion after stimulus shaping when it was preceded by trial-and-error training. Thus, the proportion of subjects meeting criterion after stimulus shaping decreased greatly when there were prior histories of either stimulus fading or trial-and-error.

Of the 16 subjects in Group II who were initially trained (first training history) with stimulus fading, only 3 (19%) met criterion on the conditional discrimination (bottom graph of Figure 7). In contrast, 2 of 4 subjects (50%) in Group I who were programmed for stimulus fading (second training history) after stimulus shaping met criterion.

Analysis of Errors on the Conditional Discrimination Test

Errors on the conditional discrimination test revealed systematic patterns of consistent form choices by some subjects. That is, when the background lines were disregarded and the responses counted as only triangle or circle responses, many subjects responded almost exclusively to one form (circle or triangle). Using a criterion of 10 or more consistent form choices (chance $p < .019$), the proportion of subjects who had not met criterion on the conditional discrimination but who showed a consistent form bias was calculated.

From Group I, only one subject of the four (Table 2) who did not meet criterion after the first history of stimulus shaping showed a bias for circles (regardless of single or multiple stripes) on the conditional discrimination. Two other subjects showed a tendency toward such perseveration.

Table 2

Proportion of subjects who did not meet criterion on the conditional discrimination, but who showed a consistent form bias.[a]

Training history	*Proportion of subjects* Circle	Triangle	Total
Group I			
Shaping ($N = 4$)	.25	.00	.25
Fading ($N = 2$)	.00[b]	.00[b]	.00
Group II			
Fading ($N = 13$)	.23	.23	.46
Shaping ($N = 11$)	.00	.09	.09
Group III			
Trial & Error ($N = 6$)	.67	.33	1.00
Shaping ($N = 6$)	.67	.16	.83

[a]Consistent form bias is defined as 10 or more choices of 1 form on the 12-trial conditional discrimination; $p < .019$.

[b]Though they did not meet the definition of 10 or more choices of 1 form or the other, 1 subject selected 9 triangles and the other selected 9 circles.

After Group II's initial stimulus fading procedures (during the first history), six subjects (nearly half; $N = 13$) met the criterion for form bias on the conditional discrimination. Of those, three chose circles and three chose triangles. Only one subject demonstrated the form bias on the conditional discrimination after the second history of stimulus shaping.

All subjects in Group III ($N = 6$) were biased toward either triangle or circle after trial-and-error training. Four of the six subjects perseverated on circles, and two on triangles. Unlike Groups I and II, this consistent form bias continued after stimulus-shaping procedures, with five of the six subjects responding almost exclusively to either the circle or triangle. Thus, perseveration after trial-and-error training persisted despite later training with shaping procedures.

DISCUSSION

Training by stimulus shaping was more effective than either stimulus fading or trial-and-error for facilitating transfer of correct responding from two simple discriminations to a conditional discrimination. Gollin and Savoy (1968) also found that training by stimulus fading did not facilitate transfer and concluded that trial-and-error procedures are more effective in this regard. In contrast, the present results clearly demonstrated the superiority of stimulus shaping over either trial-and-error or stimulus fading for effecting a transfer to the conditional discrimination. Based on these results, Gollin and Savoy's interpretation of the failure of the fading programs should be reevaluated.

The success of stimulus shaping was most likely due to (a) the selection for initial trials of stimuli that were clearly different from one another and whose shape resembled the stimuli involved in the ultimate discrimination, i.e., criterion-related stimuli (Schilmoeller & Etzel, 1977); and (b) the progressive topographical transformation of these criterion-related stimuli into the actual criterion stimuli involved in the ultimate discrimination. By contrast, the use of the noncriterion-related intensity cue in Gollin and Savoy's (1968) stimulus fading programs may have led subjects to continue to attend to the light-dark differences between the S+ and S− stimuli rather than to shift their attention to the critical form-background dimensions. The possibility for the children to label the initial cues covertly also may have contributed to the success of the stimulus shaping programs. As the configurations of the stimuli were progressively changed to their criterion-level form-background combinations, the children could have retained such labels (e.g., sun-clouds, witch-broom). The issue of whether stimulus shaping would be as successful if the initial cues cannot be easily labeled by children remains to be resolved.

The fading and shaping programs differed in that, with the fading programs, only the S− was manipulated, whereas both the S+ and S− were manipulated in the shaping programs. It is unlikely, however, that the differences are due to the manipulation of one stimulus versus both stimuli. In the study of McCleave (Baer, 1970), only the S+ was manipulated, and in Bijou's (1968) study, only the S− was manipulated. Yet both obtained successful discrimination acquisition without errors. In contrast, Koegel and Rincover (1976) manipulated both the S+ and S−; yet errorless performance did not occur at the criterion level. Thus, the selection of cues as well as the particular manipulation procedures may be more critical to successful discrimination acquisition than the manipulation of S+ only, S− only, or both S+ and S−.

The finding that training by trial-and-error usually did not facilitate transfer to the conditional discrimination contrasts with the success of the trial-and-error procedures used by Gollin (1965, 1966). One explanation may be that the conditional discrimination used by Gollin had different stimulus dimensions than those used in the present study. One form had no stripes in the background and the other had many stripes. However, the conditional discrimination in the present study involved a more difficult discrimination; the subjects were required to choose one form in the presence of a single-stripe background and another in the presence of a multiple-stripe background.

Another explanation for the failure of the subjects trained with trial-and-error to acquire the conditional discrimination in the present study was suggested by their error patterns. All subjects who did not meet criterion after trial-and-error training perseverated on either the circle or triangle on the conditional test. In training, the inclusion of yellow divider pages between the blocks of trials may have taught these children to choose one of the forms until a yellow page appeared, and then to shift to the other form. In the conditional discrimination sessions, no yellow pages signaled the shift. Thus, these children continued to choose whatever stimulus was initially associated with reinforcement. This perseveration persisted even after the subjects, initially trained with trial-and-error, were subsequently trained with stimulus shaping. The results are consistent with information of the effects of early histories of errors on subsequent discriminations (cf. Sidman & Stoddard, 1967; Stoddard & Sidman, 1967; Terrace, 1963b; Touchette, 1968). A consistent history of responding on one discrimination makes it difficult to shift to a new discrimination when this interrupts the stimulus presentations of the previous discriminations. To avoid this problem, random presentations of the two different discriminations can be arranged so that two discriminations are simultaneously formed. When this is not possible or preferable, a gradual change from single-discrimination presentations to random multiple-discrimination presentations can be programmed (Bybel & Etzel, Note 1).

The error analysis of conditional discrimination responding also indicated that half the subjects initially trained with fading had a perseverative form bias like that of the subjects initially trained with trial-and-error. This tendency to perseverate suggests that the high percentages of correct responding during fading training probably did not result from attention to the stimulus dimensions which were critical to the conditional discrimination. Those subjects in this group who did not show such perseveration may have attended to stimulus intensity during training. Thus, they would be less likely to notice the yellow divider pages or the form reversal that occurred each day. When intensity could no longer be used as the basis for responding, they shifted to other strategies which were not as readily detected as the perseverative form bias.

Most subjects who did not meet criterion on the conditional discrimination after initial training with fading also did not meet criterion after subsequent shaping training. The response patterns of those still not meeting criterion indicated that only a few showed any tendencies toward perseveration. Thus, for these subjects, the shaping procedure sufficed to disrupt the hypothesis that the discrimination was based on form, but not to establish the form-background discrimination.

The results of the present research indicate the conclusions derived from the research of Gollin and Savoy (1968) should be qualified. Some errorless procedures are more effective than trial-and-error procedures for training conditional discriminations. The superiority of stimulus shaping over stimulus fading errorless procedures for providing children with the prerequisites necessary for transferring to the conditional discrimination implicates a possible selective attention in errorless learning. The use of meaningful cues and shaping on criterion-related stimulus dimensions in the stimulus shaping procedures support this selective attention hypothesis.

REFERENCE NOTE

1. Bybel, N. W., & Etzel, B. C. A study of pretraining procedures for establishing cue relevance in the subsequent programming of a conceptual skill. Paper presented to the Society for Research in Child Development. Philadelphia, March 1973.

REFERENCES

Baer, D. M. An age-irrelevant concept of development. *Merrill-Palmer Quarterly of Behavior and Development*, 1970, **16**, 238-245.

Bijou, S. W. Studies in the experimental development of left-right concepts in retarded children using fading techniques. In Norman R. Ellis (Ed.), *International review of research in mental retardation* (Vol. 3). New York: Academic Press, 1968.

Cheney, T., & Stein, N. Fading procedures and oddity learning in kindergarten children. *Journal of Experimental Child Psychology*, 1974, **17**, 313-321.

Gollin, E. S. Factors affecting conditional discrimination in children. *Journal of Comparative and Physiological Psychology*, 1965, **40**, 422-427.

Gollin, E. S. Solution of conditional discrimination problems in young children. *Journal of Comparative and Physiological Psychology*, 1966, **62**, 454-456.

Gollin, E. S., & Savoy, P. Fading procedures and conditional discrimination in children. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 443-451.

Guralnick, M. J. Effects of distinctive feature training and instructional technique on letter and form discrimination. *American Journal of Mental Deficiency*, 1975, **80**, 202-207.

Karpicke, J., & Hearst, E. Inhibitory control and errorless discrimination learning. *Journal of the Experimental Analysis of Behavior*, 1975, **23**, 158-166.

Koegel, R. L., & Rincover, A. Some detrimental effects of using extra stimuli to guide learning in normal and autistic children. *Journal of Abnormal Child Psychology*, 1976, **4**, 59-71.

Moore, R., & Goldiamond, I. Errorless establishment of visual discrimination using fading procedures. *Journal of the Experimental Analyis of Behavior*, 1964, **7**, 269-272.

Schilmoeller, K. J., & Etzel, B. C. An experimental analysis of criterion- and noncriterion-related cues in "errorless" stimulus control procedures. In B. C. Etzel, J. M. LeBlanc, & D. M. Baer (Eds.), *New developments in behavioral research: Theory, method and application. In honor of Sidney W. Bijou*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Schwartz, S. H., Firestone, I. J., & Terry, S. Fading techniques and concept learning in children. *Psychonomic Science*, 1971, **25**, 83-84.

Sidman, M., & Stoddard, L. T. Programming perception and learning for retarded children. In N. R. Ellis (Ed.), *International review of research in mental retardation* (Vol. 2). New York: Academic Press, 1966.

Sidman, M., & Stoddard, L. T. The effectiveness of fading in programming a simultaneous form discrimination for retarded children. *Journal of the Experimental Analysis of Behavior*, 1967, **12**, 3-15.

Stoddard, L. T., & Sidman, M. The effects of errors on children's performance on a circle-ellipse discrimination. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 261-270.

Terrace, H. S. Discrimination learning with and without "errors." *Journal of the Experimental Analysis of Behavior*, 1963, **6**, 1-27. (a)

Terrace, H. S. Errorless transfer of a discrimination across two continua. *Journal of the Experimental Analysis of Behavior,* 1963, **6,** 223-232. (b)

Touchette, P. E. The effects of graduated stimulus change on the acquisition of a simple discrimination in severely retarded boys. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 39-48.

Received December 19, 1977
Final acceptance January 2, 1979